

# UNPUBLISHED PRELIMINARY DATA

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Project Title: MULTISPECTRAL PHOTOGRAPHIC EXPERIMENT

BASED ON A STATISTICAL ANALYSIS OF SPECTROMETRIC  
DATA

by

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## MULTISPECTRAL PHOTOGRAPHIC EXPERIMENT

### A. Statement of Work Performed.

During the period covered by this report the following work has been performed:

1. A set of prints was obtained from the U. S. Geological Survey, Washington, D.C., of the test site wherein this investigation was to be conducted, namely the Pisgah Crater Area in the Mojave Desert of California.
2. Within the general test site, boundaries of two test strips were delineated directly on the photos. One of these strips was centered directly over Pisgah Crater itself; the other strip sampled representative terrain conditions at one edge of the Pisgah lava flow in the vicinity of a dry lakebed known as "Lavic Lake".
3. A detailed on-the-ground study of the two test strips was made by the principal investigator in conjunction with two expert geologists of the California Division of Mines and Geology, both of whom had acquired several years of experience in mapping the geology of the Mojave Desert and environs. The result of this study was a delineation of what are presently believed to be the most significant terrain classes of the Pisgah Crater test site.
4. On the basis of this study, and while still in the field, a large number of representative sample plots were selected for each terrain class, and each was plotted on the aerial photographs.
5. Through use of a random selection process, a determination was made, for each terrain class, as to which of these representative plots would be used when obtaining spectrometric data and target-array samples.

6. At the request of the principal investigator, NASA entered into a separate contract with the Barrier Intrusion Branch, Engineer Research and Development Laboratories, Army Corps of Engineers. Under this contract Army personnel, using their portable spectrophotometer occupied each of the selected spots for the purpose of making at least 9 light reflectance measurements within each terrain class. In each instance the spot at which light reflectance measurements were taken was as indicated by the principal investigator and his assistants. A total of 100 readings were thus made of light reflectance from the terrain, wavelength-by-wavelength, for the entire range within which the spectrophotometer is operative (approximately 260 to 2,000 millimicrons).
7. From each spot at which light reflectance measurements had been made, a sample of the weathered surface material was obtained and transported to the Electrical Engineering Laboratory of the University of California at Richmond, California. Most of the surface samples were no more than about two to four inches square, but were of ample size to permit their being analyzed with the laboratory-type spectrophotometer. In several instances, however, much larger samples were obtained for later use in photographic tests to be made from a water tower on the Davis Campus of the University of California and also from Glacier Point in Yosemite Valley, as later described.
8. From each sample a representative portion was mounted with its weathered surface exposed; its spectral reflectance characteristics were then measured, wavelength-by-wavelength, with the laboratory spectrophotometer,

throughout the entire range for which that spectrophotometer is operative (400 to 1,000 millimicrons). Although this instrument has a more limited spectral range than the portable spectrophotometer's, it nonetheless covers virtually all of the spectrum in which photographic images can be obtained directly on film emulsions by means of remote reconnaissance; hence it gave information highly pertinent to the present study. A major objective in obtaining this second set of readings has been to determine the extent to which reliance might be placed in future tests, on laboratory measurements of light reflectance, rather than on the more costly and laborious field measurements.

9. The remainder of each of the samples for which a large amount of material had been selected was transported to a spot beneath a 150-foot water tower on the Davis campus of the University of California.
10. A total of 72 color panels made of Masonite sheets, each four feet square and sprayed with paints having proper hue, value and chroma characteristics (as recommended by Harry J. Keegan of the Colorimetry Laboratory, National Bureau of Standards, Washington, D. C.) also were transported to the Davis Campus.
11. Sections 4 x 5 inches in size were cut from rolls of each of the following kinds of aerial film: Aerial Ektachrome film, Camouflage Detection film, Aerial Panchromatic Super XX film, and Infrared Aerographic film. In addition 4 x 5 inch sheets were purchased of each of the following kinds of film that normally are used in taking conventional terrestrial photography: Orthochromatic, Tri-X Panchromatic,

Infrared, Ektachrome, and Ektacolor. A large assortment of narrow-band and wide-band filters also was obtained, including the Wratten 12, 25A, 47B, 61, 87C and 89B. The cut films were mounted in holders and exposed, through the use of a Speed Graphic camera, in combination with various filters. The target for these exposures consisted of the color panels and Pisgah Crater terrain samples. The camera station was the catwalk of the 150-foot water tower at Davis, beneath which the target array had been emplaced. One set of photos was taken at a high sun angle, the photographic period being centered around high noon, local sun time; a second set of photos was taken at a low sun angle, centered about the one hour period immediately preceding sunset on the same day. All of the photos were truly vertical and were taken from precisely the same camera station. A few additional photos were taken with a second Speed Graphic camera to determine the extent to which possible differences in lens optics might affect the tone or color values with which the various elements of the target array registered on the photographs.

12. Upon completion of the Davis test, materials comprising the target array were transported to a point on the floor of Yosemite Valley, which is approximately 3,000 feet lower than the selected camera station at Glacier Point. The slant range to the target array from the camera station was about 4,000 feet; consequently near vertical aerial photos could be taken which were in all respects comparable to those taken at Davis except that a much longer column of air(4,000 feet instead of 150 feet),

with correspondingly larger amounts of atmospheric haze, separated camera station from target in the Yosemite test as compared with the Davis test. Both high- and low-sun angle photos were taken at Yosemite, just as at Davis. Color temperature readings at the times of photography also were taken both at Yosemite and Davis.

13. All of the Davis and Yosemite photography was processed and printed promptly to avoid possible deterioration of the image (particularly on the color films).
14. Using a Welch Densichron with a 0.02" aperature the grey scale values or tonal densities were read for each element of the target array as imaged on each of the Davis and Yosemite negatives.
15. From a preliminary analysis of the Pisgah Crater spectrophotometric data, several black-and-white film-filter combinations were selected which appeared to offer greatest promise of providing, either individually or in concert, unique tone signatures for the various Pisgah Crater terrain classes.
16. Using a K-17 camera having a focal length of 12 inches, true aerial photographs were taken of the two selected test strips at Pisgah Crater, with each of the selected film-filter combinations; aerial photography of the same areas also was flown on the same day, with both Aerial Ektachrome film and Camouflage Detection film. For each film-filter combination, both high- and low-sun angle photography was taken, and color temperature readings were taken as they had been at Yosemite and Davis. The flight altitude was approximately 4,000 feet above the rim of Pisgah Crater. The same color panels as had been used at

both Davis and Yosemite were included in a target array that was emplaced on the rim of Pisgah Crater on the day of photography.

B. Work Currently in Progress.

1. Using the Welch Densichron, tone density values are currently being read for each terrain class and for each element of the color panel array on each of the aerial negatives that were obtained in the flights over Pisgah Crater.
2. Using all of the spectrometric data obtained with the portable spectrophotometer, and using the procedures and computer techniques described in detail in the original proposal, a complete spectrometric analysis is being made with the IBM 7090 computer at Berkeley. From this analysis it will be possible to compute the theoretical tone value with which each kind of material comprising the target array should register on each of the multispectral photographs taken at Davis, Yosemite and Pisgah Crater. These computations also incorporate accurate information on spectral sensitivities of the films used, spectral transmissivities of the filters, and color temperature of the illuminant at the time of photography.
3. An analysis similar to that described in Step 2 (above) also is being made of the spectrometric data obtained with the G.E. spectrophotometer in the laboratory at Richmond.

C. Summary Statement Regarding Present Status of the Project.

The procedure as outlined in the original proposal has been followed to date in virtually every detail. All photographs and related

data obtained thus far appear to be very satisfactory for use in the final analysis stages. The main work yet to be completed (although it currently is in progress) is that of correlating predicted with actual photographic tone signatures for each terrain class and for each color panel. If significantly higher correlations are obtained using light reflectance data obtained with the portable spectrophotometer than with the laboratory model, this will indicate the need hereafter of relying on the more troublesome, costly, time-consuming field readings. If, on the other hand, correlations obtained when using light reflectance measurements taken with the laboratory model are equally high, or nearly so, this will suggest that great savings can be made in the future by bringing terrain samples to the spectrophotometer, rather than having to take the spectrophotometer to the terrain samples.